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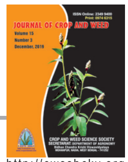

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Effect of herbicides on weed dynamics in wheat under mid hill conditions of Himachal Pradesh

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ABTRACT

Effect of seven weed control treatments viz., pre-emergence metribuzin 0.210 kg ha^{-1}, post-emergence clodinafop 0.060 kg ha^{-1}, post-emergence pinoxaden 0.060 + metsulfuron 0.004 kg ha^{-1}, post-emergence mesosulfuron 0.012 + iodosulfuron 0.0024 kg ha^{-1}, post-emergence clodinafop 0.060 + metsulfuron 0.004kg ha^{-1}, hand weeding twice (30 & 60DAS) and weedy check was evaluated on weed dynamics, yield attributes and yield of wheat at Palampur during the rabi season of 2014-15. Based upon the assessment made at 60, 120 DAS and at harvest, post-emergence application of clodinafop 0.060+metsulfuron 0.004 kg ha^{-1}provided wide spectrum control of weeds (Phalaris minor, Avena ludoviciana, Lolium temulentum among grasses and Vicia sativa, Anagallis arvensis, Coronopus didymus among broad-leaved weeds) which was as good as hand weeding twice. These treatments were followed by pinoxaden 0.060+metsulfuron 0.04 kg ha^{-1}(post) in curtailing the overall count and dry weight of weeds at different stages of observation. The yield and yield attributes were highest in clodinafop 0.060+metsulfuron 0.004 kg ha^{-1}(post) followed by pinoxaden 0.060 +metsulfuron 0.004 kg ha^{-1}(post). The least wheat grain yield was recorded under weedy check. The results suggested that clodinafop 0.060 +metsulfuron 0.004 kg ha^{-1}(post) followed by pinoxaden 0.060+metsulfuron 0.004 kg ha^{-1}(post) were the best broad-spectrum herbicide combinations in order to minimize the effect of diverse weed flora in wheat crop under the mid hills of Himachal Pradesh.

***Keywords*:** Herbicide combination, wheat, weed flora, weed management, yield

Wheat (*Triticum aestivum* L.) is the second most important cereal crop grown as staple food in world and contributes about 30-35% to the food-grain basket of India (Singh *et al.,* 2013). It is an excellent health-building food and a good source of minerals, vitamins, protein and dietary fibre. It is the second most important crop after rice. India is the second largest producer of wheat in the world after China. In Himachal Pradesh, wheat is grown on an area of 318.87 thousand hectares with an annual production of 565.74 thousand tonnes (Anonymous 2018a & 2018b). The average productivity of 1.77 t ha^{-1} in the state is far below the national average of 3.37 t ha^{-1}. Weeds are the major misfits in realizing potential yield of crops (Katara *et al*., 2012 & 2015; Kumar *et al*., 2013a & 2013b). In wheat, weeds alone account for 10 to 82% yield losses depending upon weed species, severity and duration of weed infestation and climatic conditions (Jat *et al*., 2003; Katara *et al*., 2012; Kumar *et al*., 2013a & 2013b; Fahad *et al*., 2015). Wheat gets infested with both grassy and broadleaf weeds which often leads to huge yield losses and makes the weed control more intricate (Singh *et al.,* 2002). Initial 30-45 days is the critical period of crop-weed competition in wheat crop. Chemical weed control is preferred over other weed control methods like hand weeding, which are comparatively more time consuming, costly and laborious. On instances of complex weed flora invasion constituting of both grassy and broadleaf weeds in wheat crop, the alone application of herbicides belonging to a single group is less efficient because of its narrow spectrum of weed control. In this case, the sequential or tank mix application of herbicides can be effective as a double knock for season long weed control. New ready-mix formulations have been found to be effective for the control of complex and diverse weed flora in wheat crop as it saves time, application cost and reduces herbicide impact on the environment. Keeping the above points in view, the present study on evaluation of different herbicidal treatments against complex weed flora in wheat was undertaken.

MATERIALS AND METHODS

The field experiment was conducted at Palampur (H.P) during the *rabi* season of 2014-15. The site falls in the mid hill sub-temperate sub humid agro-climatic zone of Himachal Pradesh [32°3’ N latitude, 76°3’ E longitude and 1290m altitude]. Soil of experimental site was silty clay loam in texture, acidic in reaction and medium in major available nutrients *viz.,* nitrogen, phosphorus and potassium. The experiment comprised of 7 treatments *viz.*, metribuzin 0.21 kg ha^{-1}(pre), clodinafop 0.06 kg ha^{-1}(post), pinoxaden 0.06 +metsulfuron 0.004 kg ha^{-1}(post),

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mesosulfuron 0.012 +iodosulfuron 0.0024 kg ha^{-1}(post), clodinafop 0.06 +metsulfuron 0.004 kg ha^{-1} (post), hand weeding (30 & 60 DAS) and weedy (control) was conducted in a Randomized Block Design with three replications. Wheat variety HPW- 236 was sown manually in furrows 22.5 cm apart using a seed rate of 100 kg ha^{-1}. 120 kg N, 60 kg P_2O_5 and 30 kg K_2O ha^{-1} were applied through urea (46% N), single super phosphate (16% P_2O_5) and muriate of potash (60% K_2O), respectively. One third N and whole P_2O_5 and K_2O were applied at the time of sowing. The remaining N was applied in two equal splits, first at maximum tillering and second at flower initiation stage. The rest of the management practices were in accordance with the recommended package of practices.

The species-wise weed count was recorded at 60 DAS, 120 DAS and at harvest by placing a 50 × 50 cm quadrat randomly at two spots in each plot. These samples were oven dried at 70^{o}C till constant weight and total dry matter accumulation of weeds per square metre was worked out by multiplying it with factor 4. The data obtained were subjected to statistical analysis by analysis of variance (ANOVA) for the randomized block design to test the significance of the overall differences among the treatments by the "F" test and conclusion was drawnat 5% probability level.

RESULTS AND DISCUSSION

Effect on weeds

The data on proportion of major weed species in the weedy check at maximum weed population (Fig. 1) revealed that *Avena ludoviciana* and *Phalaris minor* were the major weeds constituting 33.9 percent and 24.3 percent, respectively of the total weed population. *Lolium temulentum*, *Vicia sativa*, *Anagallis arvensis* and *Coronopus didymus* constituted 15.3 per cent, 10.6 per cent, 9.7per cent, and 6.2 per cent, respectively of the total weed population. All these weeds viz. *Phalaris minor, Avena ludoviciana, Lolium temulentum, Vicia sativa, Anagallis arvensis* and *Coronopus didymus* have showed their occurrence at all the stages of crop growth. Under mid-hill conditions of Himachal Pradesh, similar weed flora have been reported earlier by Saini and Singh (2001); Katara *et al.* (2012) and Kumar *et al.* (2013a).

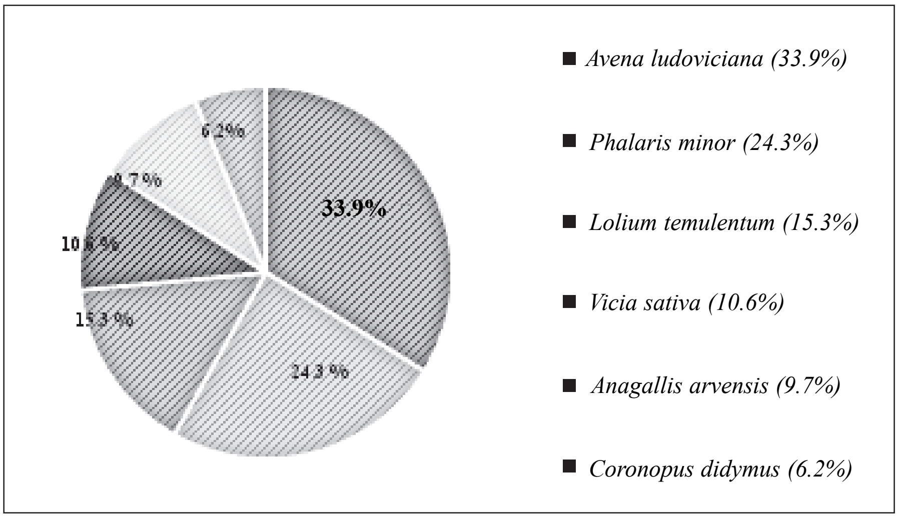

Fig. 1: Species-wise population of weeds in weedy check at maximum population stage

All weed control treatments had significantly reduced the population of *Avena ludoviciana* and *Phalaris minor* over weedy check (Table 1). It has been found that clodinafop0.06 +metsulfuron 0.004 kg ha^{-1}applied as post-emergence was as good as hand weeding twice in reducing the count of these weeds at different stages of observation. This combined application of herbicides was also at par with pinoxaden + metsulfuron 0.06+0.04 kg ha^{-1} (post) in reducing the count of *Avena ludoviciana* and *Phalaris minor* at different stage of observation. Similar results has been reported by Kumar *et al*. (2011).

Clodinafop 0.06 + metsulfuron 0.004 kg ha^{-1}(post) remaining at par with pinoxaden 0.06 + metsulfuron 0.004 kg ha^{-1}(post) resulted in significantly lower population of *Lolium temulentum* over other treatments at 60 DAS, 120 DAS and at harvest. Count and dry weight of *Vicia* sp, *A. arvensis* and *Coronopus didynus* were also significantly lower under weed control treatments over the weedy check at every stage of observation *i.e.*60 DAS,120 DAS and at harvest (Table 2). Herbicide combinations in general were found better than the sole application owing to broad-leaf weed's killing ability of metsulfuron methyl in the mixture.

Table 1: Effect of weed control treatments on grass weeds count (no. m^{-2}) in wheat

Treatment	Dose (g ha^{-1})	Time (DAS)	*Avena* 60	*Avena* 120	*Avena* harvest	*Phalaris* 60	*Phalaris* 120	*Phalaris* harvest	*Lolium* 60	*Lolium* 120	*Lolium* harvest
Metribuzin	210	Pre	4.1 (15.4)	4.1 (15.9)	3.7 (12.8)	3.4 (10.9)	3.5 (11.2)	3.2 (9.0)	2.5 (5.1)	2.5 (5.2)	2.3 (4.2)
Clodinafop	60	Post	4.5 (19.5)	4.7 (21.5)	4.5 (19.3)	3.8 (13.8)	4.0 (15.2)	3.8 (13.6)	2.7 (6.4)	2.8 (7.1)	2.7 (6.4)
Pinoxaden + metsulfuron	60+4	Post	2.8 (7.0)	3.1 (8.4)	2.5 (5.0)	2.4 (4.9)	2.6 (6.0)	2.0 (3.2)	1.8 (2.3)	1.9 (2.8)	1.6 (1.7)
Mesosulfuron + iodosulfuron	12+2.4	Post	3.8 (13.6)	3.5 (11.4)	3.0 (7.9)	3.3 (9.6)	3.0 (8.0)	2.6 (5.6)	2.3 (4.5)	2.2 (3.8)	1.9 (2.6)
Clodinafop + metsulfuron	60+4	Post	2.5 (5.1)	2.7 (6.3)	2.3 (4.5)	2.1 (3.6)	2.3 (4.4)	2.1 (3.6)	1.6 (1.7)	1.7 (2.1)	1.6 (1.5)
Hand weeding	-		1.0 (0.0)	3.5 (11.3)	3.1 (8.5)	1.0 (0.0)	3.0 (8.0)	2.6 (6.0)	1.0 (0.0)	2.2 (3.7)	1.9 (2.8)
Weedy check	-		7.9 (61.3)	8.1 (64.6)	7.4 (54.1)	6.6 (43.2)	6.8 (45.5)	6.3 (38.1)	4.6 (20.2)	4.7 (21.3)	4.3 (17.8)
LSD (0.05)	**-**		**0.32**	**0.26**	**0.35**	**0.3**	**0.2**	**0.3**	**0.2**	**0.1**	**0.2**

Data in parentheses are the means of original values

Table 2: Effect of weed control treatments on broad-leaved weeds count (no. m^{-2}) in wheat

Treatment	Dose (g ha^{-1})	Time (DAS)	*Vicia* 60	*Vicia* 120	*Vicia* Harvest	*Anagallis* 60	*Anagallis* 120	*Anagallis* harvest	*Coronopus* 60	*Coronopus* 120	*Coronopus* harvest
Metribuzin	210	Pre	2.3 (4.4)	2.4 (4.6)	2.2 (3.7)	2.4 (4.7)	2.4 (4.8)	2.2 (3.9)	2.0 (3.0)	2.0 (3.0)	1.9 (2.4)
Clodinafop	60	Post	2.6 (5.6)	2.7 (6.2)	2.6 (5.5)	2.6 (5.9)	2.7 (6.5)	2.6 (5.9)	2.2 (3.7)	2.3 (4.1)	2.2 (3.7)
Pinoxaden + metsulfuron	60+4	Post	1.7 (2.0)	1.8 (2.4)	1.6 (1.4)	1.8 (2.1)	1.9 (2.6)	1.6 (1.5)	1.5 (1.3)	1.6 (1.6)	1.4 (1.0)
Mesosulfuron + iodosulfuron	12+2.4	Post	2.2 (3.9)	2.1 (3.3)	1.8 (2.3)	2.3 (4.1)	2.1 (3.5)	1.8 (2.4)	1.9 (2.6)	1.8 (2.2)	1.6 (1.5)
Clodinafop + metsulfuron	60+4	Post	1.6 (1.5)	1.7 (1.8)	1.5 (1.3)	1.6 (1.6)	1.7 (1.9)	1.5 (1.4)	1.4 (1.0)	1.5 (1.2)	1.4 (0.9)
Hand weeding	-		1.0 (0.0)	2.1 (3.3)	1.9 (2.5)	1.0 (0.0)	2.1 (3.5)	1.9 (2.6)	1.0 (0.0)	1.8 (2.2)	1.6 (1.6)
Weedy check	-		4.3 (17.6)	4.4 (18.6)	4.1 (15.6)	4.4 (18.6)	4.5 (19.6)	4.2 (16.5)	3.6 (11.7)	3.7 (12.4)	3.4 (10.4)
LSD (0.05)	**-**		**0.2**	**0.13**	**0.2**	**0.2**	**0.1**	**0.2**	**0.1**	**0.1**	**0.1**

Data in parentheses are the means of original values

The combined count and dry weight of different weed species were also significantly lower under herbicidal treatments (Table 3). In general, combined application of clodinafop 0.06 + metsulfuron 0.004 kg ha^{-1} and pinoxaden + metsulfuron were found superior over the sole application of herbicides in reducing the total weed count and total dry matter at different stage of observation.

Effect on crop

Different weed control treatments significantly affected the days taken to 50% earing, spikes/m row length, length of spike, grain weight/spike, biological yield, grain yield, straw yield and harvest index of wheat crop compared to that of unweeded control plot (Table 4). It has been found that application of clodinafop 0.060 +metsulfuron 0.004 kg ha^{-1}(post) remaining at par with pinoxaden 0.06 + metsulfuron 0.004 kg ha^{-1}(post) significantly reduced the days to earing as compared to weedy check. This was mainly due to the removal of competition by weeds. These treatments were significantly superior in having more number of spikes/m row length and with more length as compared to all other treatments. In case of grain weight per spike,

Table 3: Effect of weed control treatments on total weed count (no. m^{-2}) and total weed dry weight (no. m^{-2}) in wheat

Treatment	Dose (g ha^{-1})	Time (DAS)	Total weed count			Total weed dry wt.		
			60	120	harvest	60	120	harvest
Metribuzin	210	Pre	6.7 (43.5)	6.8 (44.7)	6.1 (36.0)	2.3 (4.3)	7.5 (54.9)	8.1 (64.8)
Clodinafop	60	Post	7.5 (55.0)	7.8 (60.6)	7.4 (54.3)	2.6 (5.7)	8.3 (67.2)	8.8 (76.8)
Pinoxaden + metsulfuron	60+4	Post	4.5 (19.7)	5.0 (23.8)	3.7 (12.6)	1.5 (1.2)	5.9 (33.8)	6.2 (36.9)
Mesosulfuron + iodosulfuron	12+2.4	Post	6.3 (38.3)	5.7 (32.2)	4.8 (22.4)	2.1 (3.5)	6.8 (45.5)	7.5 (55.0)
Clodinafop + metsulfuron	60+4	Post	3.9 (14.5)	4.3 (17.6)	3.9 (14.2)	1.3 (0.8)	5.6 (29.9)	5.7 (31.2)
Hand weeding	-		1.0 (0.0)	5.7 (32.0)	5.0 (24.0)	1.0 (0.0)	6.5 (41.6)	7.2 (51.5)
Weedy check	-		13.2 (172.7)	13.5 (181.9)	12.4 (152.5)	7.6 (56.6)	13.7 (186.0)	5.3 (233.8)
LSD (0.05)	**-**		**0.5**	**0.4**	**0.6**	**2.0**	**0.4**	**0.4**

Data in parentheses are the means of original values

Table 4: Effect of treatments on days to 50% earing, yield attributes and yield of wheat

Treatment	Dose (g ha^{-1})	Time (DAS)	Days to 50 % earing	Spikes/m row length (cm)	Grain weight/ spike (g)	Grain yield (kg ha^{-1})	Harvest index
Metribuzin	210	Pre	108.3	39.3	2.5	3310	0.35
Clodinafop	60	Post	109.3	36.7	2.4	2824	0.35
Pinoxaden + metsulfuron	60+4	Post	106.0	46.2	3.0	4200	0.37
Mesosulfuron + iodosulfuron	12+2.4	Post	108.0	42.5	2.7	3611	0.36
Clodinafop + metsulfuron	60+4	Post	105.7	47.3	3.1	4445	0.38
Hand weeding	-	-	108.3	40.8	2.7	3403	0.36
Weedy check	-	-	112.0	27.3	1.6	1920	0.32
LSD (0.05)	**-**	**-**	**1.6**	**4.8**	**0.2**	**333**	**0.02**

significantly higher values were obtained in plots receiving clodinafop 0.060 +metsulfuron 0.004 kg ha^{-1}(post) application which was statistically at par with pinoxaden 0.060 +metsulfuron 0.04 kg ha^{-1} (post). This might be because of less weed competition and more production and translocation of photosynthates to the grain. For biological yield, grain yield and straw yield also, application of clodinafop 0.060 +metsulfuron 0.004 kg ha^{-1}(post) was at par with pinoxaden 0.060 +metsulfuron 0.004 kg ha^{-1}(post) as compared to all other weed control treatments. These treatments also scored the highest harvest index compared to all other treatments. Similar observations with respect to clodinafop+metsulfuronon to increase yield attributes and yield were also reported from Hisar by Malik *et al.*(2013).

Since clodinafop 0.060 + metsulfuron 0.004 kg ha^{-1}(post) and pinoxaden 0.06 + metsulfuron 0.004 kg ha^{-1}were at par with each other to reduce species-wise and total weed density as well as dry weight of weeds and to increase grain and straw yield, they can be recommended for broad-spectrum weed management in wheat than their sole application under mid hill conditions of Himachal Pradesh.

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